p631
Q13

$$E = mc^2$$
$$E = 1.67\times10^{-27}\,kg\,(3.00\times10^{8}\,m/s)^2$$
$$=$$

a) 1.67x9=15.03
1.5×10^{-10}J
b) 1eV = 1.602×10^{-19}J
1.5/1.602=0.9363
9.4×10^{8}eV

c) proton and anti-proton collide and annihilate
both have the same mass
E for both = 2 x E for a proton
3.0×10^{-10}J or 9.4x2=18.8 1.9×10^{9}eV

Nuclear Reactors
Fission reactors
Fission is when a large nucleus decays into 2 smaller daughter nuclei (not Helium 4)

What isotopes are fissionable?
Uranium 235 is fissionable and the most commonly used, but most natural Uranium is 238. Enrichment is getting rid of Uranium 238

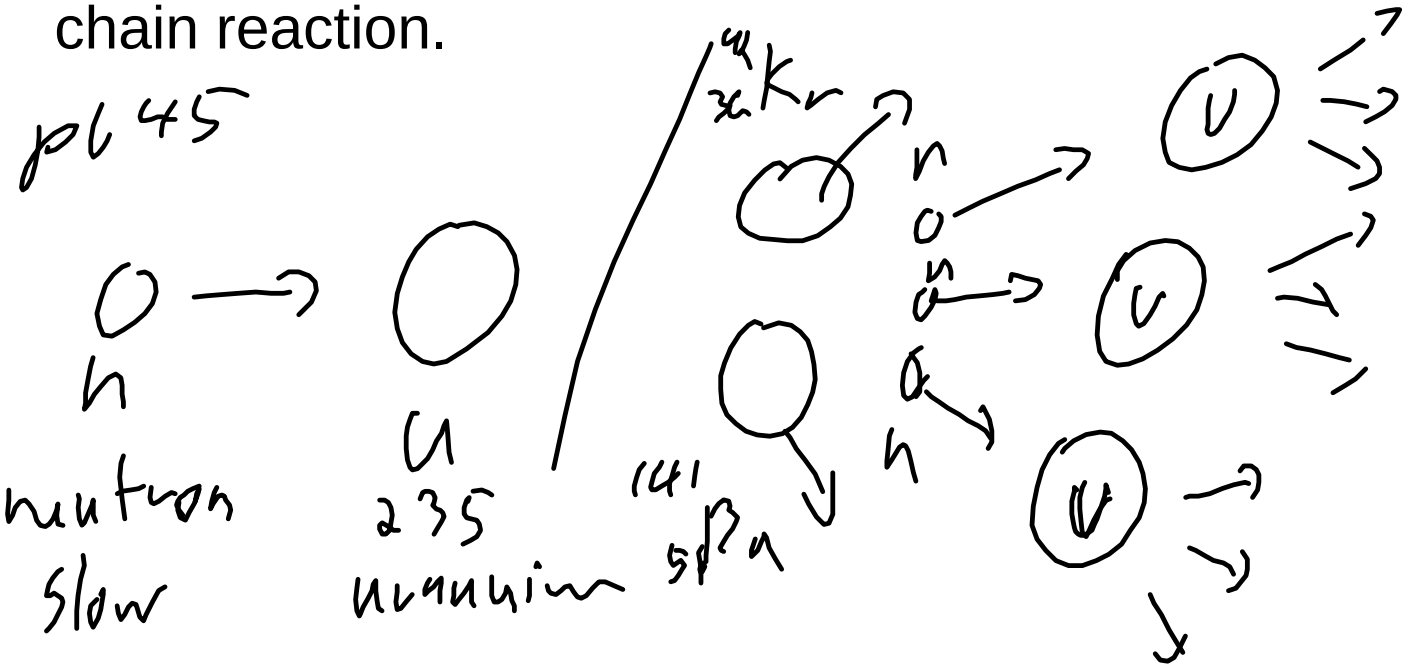
and getting more Uranium 235.

Plutonium 239 is fissionable but not naturally occurring in reasonable quantities. You can make Plutonium 239 by bombarding Uranium 238 with neutrons, and then it undergoes 2 beta decays. Done in Breeder reactors.

Thorium can be made into fissionable products. More abundant than Uranium.

Parts of a nuclear reactor and their roles:

Fuel rods - pellets of fuel that are below the critical mass - mass required for a uncontrolled chain reaction.



the reaction produces neutrons that can hit other Uranium nuclei and produce a chain reaction, that increases exponentially.
The daughter nuclei, Krypton 92 and Barium

141 in this example, are radioactive. Deal with the waste.

Control Rods - Rods of a material that absorbs the neutrons, slowing the reaction. Made of materials like Cadmium.

Moderator - slows the neutrons **increasing** the rate of reaction. Chernobyl used graphite as their moderator - flamable - big explosion in 1984. Most reactors use heavy water as a moderator.

Heat from the reaction boils water, that turns a steam turbine, moving a magnet near a coil of wire, inducing electric current.

Waste heat goes into cooling towers and river.

Fusion Reactors:

no radioactive waste, produce more energy per atom and cheap fuel. Why don't we power everything by fusion?

Need very high temperatures and pressures to force the nuclei together (both positive).

p652 Q9,10, CR 2.1-2.4 p655 Q20, 23
study for quiz

study for quiz

tritium Hydrogen-3 = 3.0160492 u
deuterium Hydrogen-2 = 2.0135532 u
Helium-4 = 4.002602 u

Nuclear Reactors
Fission Reactor
Produce lots of energy
Fission is the splitting of a large nucleus into 2 smaller daughter nuclei (not Helium 4)
releases energy - some mass is changed into energy - binding energy per nucleon increases

Fissionable materials:

Uranium 235 is fissionable but the more common isotope, U238 is not directly fissionable. U238 can be transmuted into Plutonium 239 by firing neutrons into U238 and it will undergo 2 beta decays.
Plutonium 239 is fissionable.

Thorium can be transmuted into Uranium and be fissionable. Thorium is more common.

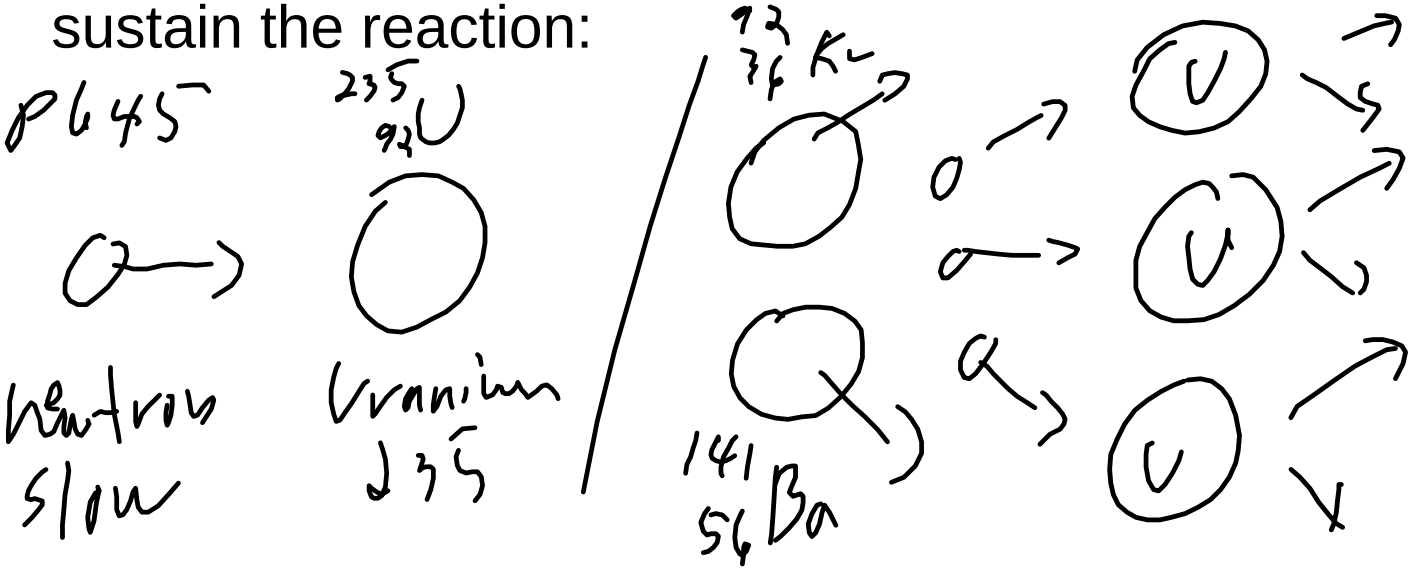
Enrichment - get rid of U238 and get more

U235 in your fuel.

Parts of a Nuclear Reactor:

Neutron source to get the reaction going. (Polonium and Aluminum)

Fuel rods - Fuel pellets that are lower than critical mass - mass needed for chain reaction put the pellets together, you get enough to sustain the reaction:



$$^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3({}^{1}_{0}n)$$

Neutrons can trigger another reaction

The neutrons cause a chain reaction where more nuclei react and it can increase exponentially.

Control Rods - Material that absorbs the neutrons, slowing the reaction. Cadmium.

Moderator - Material that slows the neutrons increasing the rate of the reaction.
Chernobyl reactor - used graphite - flammable
Most reactors - use heavy water (water with deuterium in place of a hydrogen).

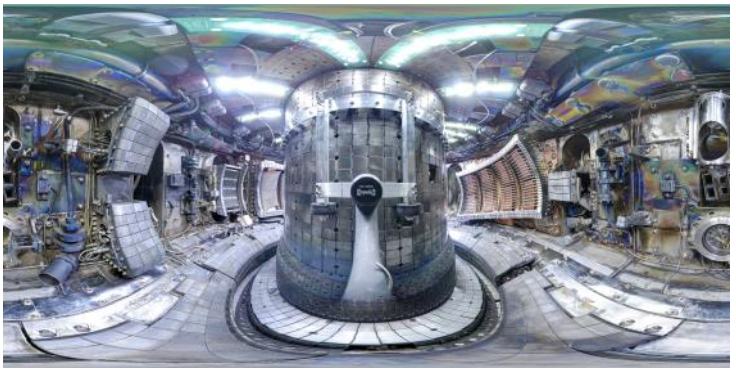
The energy is used to boil water and the steam turns a turbine (magnet near a coil of wire) producing electrical current through electromagnetic induction.

The hot water is cooled in the cooling towers.

Products of fission are radioactive.

Fusion reactors
Hydrogen fuses and produces lots of energy.
Limited radioactive waste, lots of fuel.

Need very high temperatures and pressures for the nucleus to overcome electrostatic repulsion. (positive)



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